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Exploring the Relationship between Level of Cognitive Ability in Mathematics within Two Different Schools in Tapah

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ABSTRACT

Cognitive ability in Mathematics has been widely discussed in various platforms. A total of 248 students from two schools in Tapah was selected in this study. The result showed that the cognitive level for ~~of~~ the students of SMK Sri Tapah and SMK Buyong Adil was found to be at moderate level where the score for each of the cognitive level lies *between* 20% to 50 %. Furthermore, this study identified the existence of a moderate relationship between all cognitive levels by using Correlation Analysis. Meanwhile, Mann Whitney test was used to test the differences of students performance from both schools and it showed that the students from SMK Buyong Adil were statistically greater for Knowing level (C1) SMK Buyong Adil (Mdn=0.5 marks), Understanding level (C2) (Mdn=0.5 marks), Applying level (C3) (Mdn=0.5 marks), Creating level (C6) (Mdn=1 marks) than students from SMK Sri Tapah. However, students from SMK Sri Tapah were found to be greater in Evaluating level (C5) (Mdn=1 marks) than students from SMK Buyong Adil. Overall this study found that the level of cognitive ability in both schools in Tapah is still at a moderate level and have to be improved.

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1. Introduction

Bloom's Taxonomy was created by Benjamin Bloom in 1956 as kind of a way to categorize the levels of reasoning skills required in classroom situations. Bloom identified three learning categories. Firstly, “Cognitive” that focuses on mental skills or knowledge. Secondly, “Effective” is more specific growth in feelings or emotional areas and attitude. Thirdly, “Psychomotor” focuses in on manual or physical capabilities. Majority of the teachers in Malaysia use this these skills in their classrooms. These different categories of learning may help them to assess their students in various views. Bloom's Taxonomy also can assist teachers when creating questions to test the student's ability in the written examination. This is because teaching and learning are goal-directed, mindful, and effortful enterprises [1].

The cognitive level is one of the sets of hierarchical models that have been debated since 1956. It was designed to enable students to remember, understand, apply, analyze, evaluate, and create to improve learning in mathematics. First, “Knowing or Remembering” that is to retrieve, recall, or acknowledge the relevant information from a long-term memory. Secondly, “Understanding” that is to demonstrate a comprehension through one or additional types of rationalization. Thirdly, “Applying” which is to carry out or employ a procedure through executing or implementing [2]. On the other hand, “Analyzing” means to break material into its constituent elements and confirm how these parts are related to one another or an overall structure or purpose. Then, “Evaluating” is to make judgments based on characteristics and standards. Lastly, “Creating” which means to put parts along to generate a replacement coherent or a useful whole; reorganizing elements into a new pattern or structure [3].

In Malaysia, students have improved in Mathematics, Reading and Science under the Program for International Student Assessment (PISA) 2015. According to the results released by the Organization for Economic Cooperation and Development (OECD), Malaysia scored 446 points for Mathematics in PISA 2015. Education director-general Datuk Dr Amin Senin said the results achieved in PISA 2015 survey demonstrated that Malaysia was moving towards hitting the worldwide average score of 490 points in Mathematics. He attributed the improved outcomes in PISA 2015 to the implementation of the higher-order thinking skills. Thus, in order to ensure this implementation is achieved, it is necessary for the educators to be able to address their student’s level of ability in understanding of the course they enrolled [4].

Mathematics is a very important subject. It is used in our daily lives since it is being educated and taught at all academic institutions in the world from pre-school to higher learning organizations namely, kindergartens, both primary and secondary schools, universities, and colleges. Mathematics can be difficult to learn at times. It involves applying formulae, using measurement, calculate numbers, and spatial perception problems. Students may get bored and refused to understand mathematics if they could not solve mathematical problems. Therefore, teachers must play an important role by encouraging their students to learn a good basic knowledge of mathematics [5].

Mathematics ability is a crucial part that involved problem-solving and calculations. However, many students faced math difficulties in memorizing mathematical facts, concepts, rules, formulas, and procedures. Therefore, it is hard for students to improve their performance advanced problems in mathematics. Some of the students were slow in understanding math concepts in word problems. Thus, cognitive skills in Bloom's Taxonomy were introduced to improve their math difficulties. Cognitive abilities are built from a theoretical perspective to high-level thinking, and it can apply in all education systems. Although the cognitive level has existed in the education system, there are reasons why the students do not perform well in the examination. The students have difficulty in understanding probability and statistical concepts may be due to less or no curriculum instruction for probability given at the elementary school level [6].

This problem may have led to the lack of a concerted effort in the provision of cognitive skills by educators in mathematics subjects. Therefore, educators should observe and improve in learning cognitive abilities to students. However, thinking flexibly, applying in students’ prior knowledge, and remaining open to continuous learning should be observed by the educators because they can use mathematics concepts in their daily life. It is because a complex idea in science can only be understood if more fundamental concepts involved in the formation of a new concept that have been fully understood [5].

Thus, this study will enable us to recognize the student's level of mathematical ability that suits in solving the mathematical problems for the students. So, this research is assumed to help the teachers to understand their student's skills in a mathematical subject. Ultimately, they would be able to make a plan in formulating actual questions that suit their student's level of ability.

The aims of this study are:

i. To determine the median score of cognitive levels that can help to improve the score in mathematical subject for each school.
ii. To determine the relationship among the cognitive levels which are Knowing (C1), Understanding (C2), Applying (C3), Evaluating (C5) and Creating (C6) for both schools.
iii. To determine the difference(s) of student's performance between Sekolah Menengah Kebangsaan Sri Tapah and Sekolah Menengah Kebangsaan Buyong Adil.

2. Literature Review

2.1 Mathematics Problem Solving

Mathematics is considered as the arrangement of standards that is to be understood, which deals with arithmetical counts, sets of formula to be remembered and mysterious algebraic equations. Teachers at school should focus on the improvement of students' skills in solving mathematical problems because problem-solving is an essential aspect of mathematics learning and development processes. Problem-solving is a valued component in school's mathematics curricula in all parts of the world, although there are differences from one country to another. Problem-solving is a method for developing the thinking skills. Just as important as problem-solving is, [7] have also claimed that logical thinking skills are one of the important factors that determine the students' abilities.

The strategies of cognitive teaching have improved problem-solving reliability mathematical difficulties. [7] stated that students' analysis, synthesis, and evaluation skills could be enhanced if High Order Thinking Skill (HOTS) are associated with cognitive processes of Bloom's Taxonomy in their learning. Instead of solving algorithmic problems, HOTS thinking skills are also capable of solving various non-algorithmic problems that include both critical and creative thinking. However, [8] found that the frequency of tasks promoting Lower order thinking skills (LOTS) is higher than that of tasks promoting HOTS, demonstrating that teachers focus more on activating prior knowledge than on developing problem-solving skills.

2.2 Cognitive Domain

Cognitive domain consists of an intellectual aspect as well as the function of processing information, knowledge and mentality skills [9]. Creative thinking is usually related to cognitive skills in finding a new solution for a problem. Working memory also has a significant influence on cognitive processing to achieve learning and academic performance.

There are many frameworks proposed by researchers when measure cognitive abilities, but the most well-known and widely used framework is Bloom's Taxonomy [9]. Researchers in [10] had employs terminology from Bloom's categorization to describe attributes of learning while searching for information. Thus [11] elaborated that there are two hierarchy chart of the cognitive domain. Bloom's is based on the work of Benjamin Bloom. The stages in Bloom's Taxonomy 1956 are Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. The learning process will naturally take place when gradually followed the hierarchical chart [12]. The second hierarchy chart is the revised taxonomy chart. The stages are Remembering, Understanding, Applying, Analysing, Evaluating, and Creating [13]**.** In the proposed reconsidered Bloom's Taxonomy, with regards of the advanced education settings, all domains of cognitive progression of learning are repeating, which may occur in a dynamic sequence and where students and teachers have the autonomy to move their way to deal with it at any point of time during a learning venture [13]. The free dimensional mode consolidating the past learned experience and reflective analysis of the new knowledge enables them to figure-out the learning process [12].

3. Methodology

This study used the cross-sectional design that involved two schools in Tapah. The target population was all Form 4 students from two different schools (SMK Buyong Adil and SMK Sri Tapah), with a total sample of 248 students. A set of mathematical questions from Chapter 2 (Quadratic Equations) was given based on their syllabus. A stratified random sampling was used to select the samples. This technique is suitable to use since it can represent all the classes in the schools. A set containing 50 math questions was provided to each of the samples with the help of

school teachers. The items were classified into six cognitive levels with two hours given to answer the questionnaires. This study used a combination of descriptive and inferential statistic methods as the analysis strategy selection.

3.1 Descriptive Statistics

Descriptive analysis was used to determine the median score of the cognitive level in order to achieve the optimal cognitive level which then helps to improve the score in the Mathematic subject. This study enables the teachers to look into their students' abilities based on the cognitive level for the Quadratic equation topic. Next, it will help the teachers to rectify the problem by improving the materials in teaching and learning method so that their students are able to have a better understanding and scores in this subject.

3.2 Correlation Analysis

Correlation is a statistical instrument used to analyze the relationship between two or more variables. It also deals with the interpretation and evaluation of the interaction between two or more mathematical sets. Two methods that can be used to investigate the correlation of the variables are the graphical method (scatter plot) and the numerical method (correlation coefficient). By using a visual form, the graph shows the mutual variance between pairs of values that offer an indication of the relationship between the two variables. When the dots scatter along a straight line, the correlation is linear. If the dots scattered along a curve, the correlation is non-linear; if they are circular and spread all over without a pattern, there can be no connection between the variables. As for the numerical method, the correlation coefficient is not equal to 1 (+1 or -1). If its value nearing is 1, it indicates a strong linear relationship, and if its value is approaching 0, it shows the absence of a linear relationship. Thus, the zero value of the correlation coefficient does not imply that there is no relationship between the two variables or that they are independent of each other. The Pearson Product Moment of Correlation and Spearman Rank are two types of correlation coefficient that can be computed. Pearson's coefficient measures the linear relationship between two variables. Meanwhile, the Spearman's coefficient measures the sequence at the point level, where it would assess whether the regions with strong clusters also tend to have better competitive outcomes. Thus in this study, the Spearman Rank correlation coefficient was used to investigate the relationship between these variable. The calculation of Spearman Rank is as below:

$$1 - \frac{6\sum d^2}{n(n-1)} \tag{1}$$

This study also used a correlation matrix to investigate whether there is a relationship among cognitive levels in Mathematics subject which consist of five types of cognitive level questions which are Knowing (C1), Understanding (C2), Applying (C3), Evaluating (C5), and Creating (C6). The total questions in this questionnaire are 50 questions, and each ten items represents one cognitive level.

3.3 Mann Whitney U test

Mann Whitney U test was used to determine the differences in students' performance between these two schools in Tapah. This test is more broadly used to interpret whether there are differences in the "distributions" of two groups or discrepancies in the "medians" of two groups. The Mann-Whitney U test null hypothesis (H_0) stipulates that the two groups come from the same population.

The test statistic for the Mann Whitney U Test is denoted **U** and is the *smaller* of $\mathbf{U_1}$ and $\mathbf{U_2}$, as defined below:

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \tag{2}$$

$$U_2 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_2 \tag{3}$$

where R_1 = sum of the ranks for Group 1

R_2 = sum of the ranks for Group 2

In other terms, it stipulates that the two independent groups are homogeneous and have the same distribution. The two variables corresponding to the two groups, represented by two continuous cumulative distributions, are then called stochastically equal. If a two-sided or two-tailed test is required, an alternative hypothesis (H_1) in which the null hypothesis will be tested to stipulate that the first group data distribution differs from the second group data distribution. This method was used to test the differences in students' performance on each cognitive level between the two schools.

4. Result and Discussion

4.1 Description of the respondents' background.

Figure 1 presents the respondents' background.

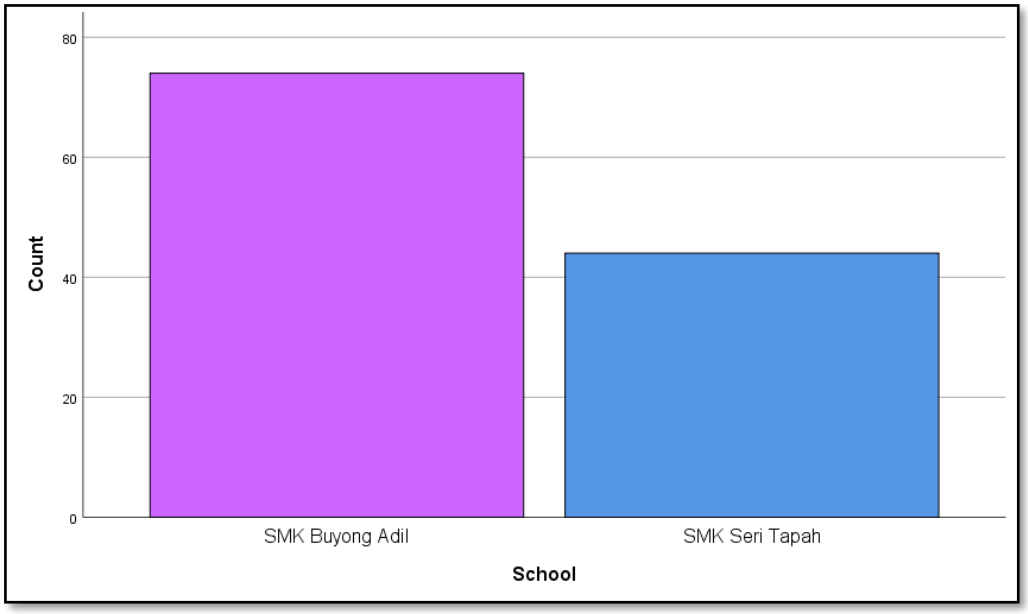

Figure 1. Bar chart of the students who participate in this study

In this study, SMK Buyong Adil students dominated at 62.71%, and it was only 37.29% for SMK Seri Tapah students (Figure 1). In terms of mean score breakdown (Table 1), for Knowing level (C1), the average score of students from SMK Sri Tapah was 4.64 marks (SD=2.21) while the average score of students from SMK Buyong Adil was 4.62 marks (SD=2.55). Meanwhile, for Understanding level (C2), the average score of students from SMK Sri Tapah was 5.00 marks (SD=2.37), and the average score of students from SMK Buyong Adil was 5.39 marks (SD=2.47). As for Applying level (C3), the average score of students from SMK Sri Tapah was 3.98 marks (SD=1.80), while the average score of students from SMK Buyong Adil was 3.24 marks (SD=1.94).

For Cognitive level Evaluating (C5) and Creating (C6), this study found that the average score of students from SMK Sri Tapah was 3.61 marks (SD=2.15) and 2.43 marks (SD=1.32), respectively. The students' performance from SMK Buyong Adil was not much of a different from SMK Sri Tapah where the average score was 3.24 marks (SD=1.94) for Evaluating level and 2.68 marks (SD=1.48) for Creating (C6) level. Overall, students' performance score based on their cognitive levels obtained from both schools were on a moderate scale since the highest mark is 5 marks out of 10 marks.

Table 1. Summary Statistics

Cognitive Level	Mean score;SD	
	SMK Sri Tapah	SMK Buyong Adil
Knowing (C1)	4.64;2.21	4.62;2.55
Understanding (C2)	5.00;2.37	5.39;2.47
Applying(C3)	3.98;1.80	4.41;1.78
Evaluating(C5)	3.61;2.15	3.24;1.94
Creating(C6)	2.43;1.32	2.68;1.48

4.2 Correlation Analysis

The correlation analysis test was conducted to test the presence of relationship between each level of cognitive ability. Table 2 shows the results for five different levels of cognitive ability. The results for the Spearman Rank of correlation suggest that Knowing (C1) and Understanding (C2) were found to be a significant moderate positive relationship (r(118)=0.581,p=0.000). Other than that, Knowing(C1) and Understanding(C2) (r(118)=0.433,p=0.000), Knowing (C1) and Evaluating(C5) (r(118)=0.449,p=0.000) as well as Knowing (C1) and Creating(C6**)** (r(118)=0.201,p=0.000) were found to be significant low positive relationship as the *p*-value was less than 5% level of significance.

Table 2. Correlation Matrix for C1-C6

	C1	C2	C3	C5	C6
C1	1.000	0.581**	0.433**	0.449**	0.201**
C2		1.000	0.451**	0.425**	0.077
C3			1.000	0.329**	0.081
C5				1.0000	0.246**
C6					1.0000

**significance level at 5%

Overall, this study found that there is a significant difference between the cognitive levels of ability in students' performance. For example, if the Cognitive level 1 (C1) increases, Cognitive level 2 (C2) will also be increased. However, the relationship was found to be a moderate relationship. It means that each level corresponded to the previous level. According to [15] it is stated that the mastery of prerequisite materials influences the students' success in learning before accepting new material. Therefore, before proceeding to the next level of cognitive ability, the educator should first observe their students whether they have passed that level or not.

4.3 Mann Whitney test

Table 3 shows the results of testing the differences in students' cognitive level from two schools (SMK Buyong Adil and SMK Sri Tapah). Based on the Mann–Whitney test, there was a significant difference for students' cognitive level from both schools (p-value<0.05) at all levels. Overall, the different performance of students from SMK Buyong Adil was found statistically greater for Knowing story (C1) SMK Buyong Adil (Mdn=0.5 marks), Understanding level (C2) (Mdn=0.5 marks), Applying level (C3) (Mdn=0.5 marks), Creating level (C6) (Mdn=1 marks) than students from SMK Sri Tapah. However, students from SMK Sri Tapah found to be greater in the Evaluating level (C5) (Mdn=1 marks) than students from SMK Buyong Adil.

Table 3. Summary of Mann Whitney Test

Cognitive Level	**SMK Buyong Adil**			**SMK Sri Tapah**		
	Median	Z-statistics	p-value	Median	Z-statistics	p-value
Knowing (C1)	4.5	5624	<0.001**	4	1892	<0.001**
Understanding (C2)	5.5	5624	<0.001**	5	1892	<0.001**
Applying(C3)	4.5	5776	<0.001**	4	1804	<0.001**
Evaluating(C5)	3	5548	<0.001**	4	1694	<0.001**
Creating(C6)	3	5472	<0.001**	2	1628	<0.001**

**significance level at 5%

5. Conclusion

This study applied data on the students' performance from two schools in Tapah. A total of 118 students with different cognitive levels answered 20 multiple choice questions based on the topic of Quadratic Equations with the help of their teachers. The result should be reviewed to improve the students' cognitive level by enhancing the learning materials or the teaching method. The overall results show the students' cognitive level for Chapter 2's (Quadratic Equation) topic from both schools were at a moderate level, where the score for each cognitive level lies around 20% to 50%. Similarly, [12] also found that students are still struggling within the thinking process, especially at a complex level of thinking ability, such as analyzing and creating.

This study managed to uncover the existence of a moderate relationship between all cognitive levels by using Correlation Analysis. This study also revealed that the lowest level of cognitive ability plays a significant role in scoring the topic. Students need to master the topic at the first level of cognitive ability which is Knowing (C1) first before they can move to a higher cognitive level. Students' prior knowledge in each topic is essential in developing their understanding. If they did not do well at the Knowing level, they would tend to memorize all the techniques or formula. As a result, when the teacher moves further into a complex topic at a higher level, the students will be having difficulties because they were unable to achieve the lowest level Knowing (C1).

Based on this study, there are two things to look into; the teachers and the students. The teachers' professional development programs related to the assessment and test item development are still lack of direct practices in developing HOTS items. Hence, it is necessary to plan an in-depth teachers' professional development program to enhance their skills in developing HOTS items with a full guidance and coaching strategy. On the student's side, teachers should be able to determine their student's learning differences. As a result, the cooperation from both (students and teachers) will help to improve the HOTs development in Malaysia.

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